Regenerative Organic Farming: A Solution to Global Warming

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Introduction

Agriculture is an undervalued and underestimated climate change tool that could be one of the most powerful strategies in the fight against global warming. Nearly 30 years of Rodale Institute soil carbon data show conclusively that improved global terrestrial stewardship--specifically including regenerative organic agricultural practices--can be the most effective currently available strategy for mitigating CO2 emissions.

Rodale Institute's Farming Systems Trial® (FST) is the longest-running side-by-side comparison of organic and conventional farming systems in the U.S. and one of the oldest trials in the world. It has documented the benefits of an integrated systems approach to farming using regenerative organic practices. These include cover crops, composting and crop rotation to reduce atmospheric carbon dioxide by pulling it from the air and storing it in the soil as carbon. Results from these practices—corroborated at other research centers that include University of California at Davis, University of Illinois, Iowa State University and USDA Beltsville, Maryland, research facility—reiterate the vast, untapped potential of organic agricultural practices to solve global warming.

Agricultural carbon sequestration has the potential to substantially mitigate global warming impacts. When using biologically based regenerative practices, this dramatic benefit can be accomplished with no decrease in yields or farmer profits. Even though climate and soil type affect sequestration capacities, these multiple research efforts verify that practical organic agriculture, if practiced on the planet's 3.5 billion tillable acres, could sequester nearly 40 percent of current CO2 emissions.

Rodale Institute advocates a rapid, nationwide transition from today's prevailing, petroleum-based farming methods to more advanced "post-modern" systems incorporating best practices based on replicated research. We call this approach regenerative organic agriculture to signify its focus on renewing resources through complementary biological systems which feed and improve the soil as well as avoiding harmful synthetic inputs. This is the full meaning of our preferred farming style in this discussion.

The problem with modern agriculture

Modern farming practices are one of the largest contributors to global warming.

Current farming practices are not sustainable for a number of reasons. Some Midwestern soils that in the 1950s were composed of up to 20 percent carbon are now between 1- and 2-percent carbon. This carbon loss contributes to: soil erosion, by degrading soil structure; increasing vulnerability to drought, by greatly reducing the level of water-holding carbon in the soil; and the loss of soil's native nutrient value.

In addition, prevailing farming practices break down soil carbon into carbon dioxide that is released into the atmosphere, greatly contributing to global warming. Surprising analysis of the nation's oldest continuous cropping test plots in Illinois showed that, contrary to long-held beliefs, nitrogen fertilization does not build up soil organic matter. New data from U.S. government research show that with agriculture using chemical fertilizers and herbicides, the U.S. food system contributes nearly 20 percent of the nation's carbon dioxide emissions. On a global scale, figures from the Intergovernmental Panel on Climate Change (IPCC) say that agricultural land use contributes 12 per cent of global greenhouse gas emissions.

Other negative effects of the modern-farming paradigm include: nutrient overload in our waterways from the use of synthetic nitrogen, loss of energy reserves due to the abundant use of petrol-based chemicals (which put an increasing financial burden on farmers as oil prices rise), degradation of our soils (due to mono-cropping that requires use of synthetic fertilizer for fertility) and animal health and welfare concerns.

The soil solution: solving global warming…and more

Rodale Institute's Farming Systems Trial (FST) was the first study that proved regenerative organic agricultural practices store or sequester carbon in the soil by removing it from the air, thereby significantly reversing the impact of global warming.

Regenerative organic farming methods can transform agriculture from part of the global warming problem to a major part of the solution, by changing how we farm. Farmers can transition to new practices relatively quickly and inexpensively using low-cost tools.

Carbon dioxide levels are minimized in summer when lush vegetation promotes a sponging action, and are maximized in winter when plants go dormant. However, the greenhouse gas sponging ability of the soil itself may make more of a difference than what's growing on the land. On a global scale, soils hold more than twice as much carbon (an estimated 1.74 trillion U.S. tons) as does terrestrial vegetation (672 billion U.S. tons). Data from Rodale Institute and other studies indicate that regenerative and organic practices can dramatically alter the carbon storage of arable lands, building soil "humic" substances (also known as soil organic matter) that remain as stable carbon compounds for many years.

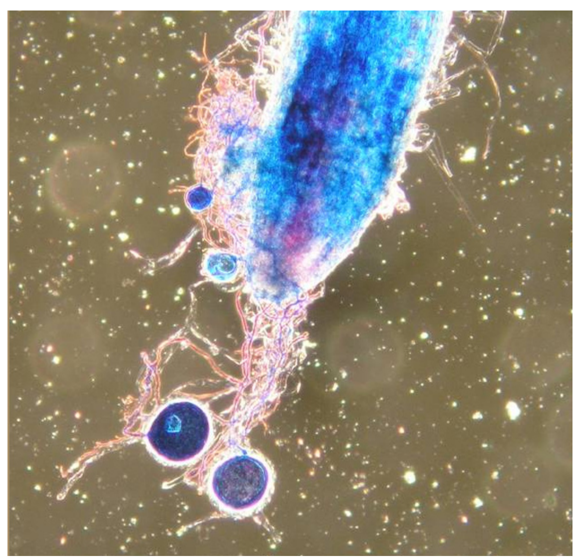
The key to greater, more stable carbon sequestration lies in the handling of soil organic matter (SOM). Because SOM is primarily carbon, increases in these levels will be directly correlated with carbon sequestration. While prevailing farming practices using synthetic inputs typically deplete SOM, regenerative farming practices, including the integration of crop and animal production, build it.

Before forests and grasslands were converted to field agriculture, SOM generally composed 6 to 10 percent of the soil volume, well over the 1- to 3-percent levels typical of today's agricultural field systems. Building soil organic matter by better nurturing our agricultural lands can capture the excess atmospheric carbon dioxide and begin returning this lost carbon to the soil. Forests and rangelands hold a greater capacity for carbon sequestration than the aboveground biomass measurements often used in equating their values.

Organically managed soils can convert carbon from a greenhouse gas into a food-producing asset. Soils that are rich in carbon conserve water and support healthier plants that are more resistant to drought stress, pests and diseases. Our studies of organic systems have shown an increase of almost 30 percent in-soil carbon over 27 years. The petroleum-based system showed no significant increase in soil carbon in the same time period and some studies have shown that these systems, in fact, may lose carbon.

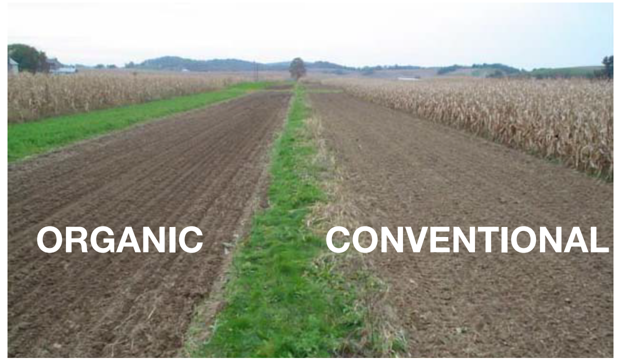
Researchers are fleshing out the mechanisms by which this soil carbon sequestration takes place. One of the most significant findings is the high correlation between increased soil carbon levels and very high amounts of mycorrhizal fungi. These fungi help slow down the decay of organic matter. Beginning with our Farming Systems Trial, collaborative studies by the USDA's Agriculture Research Service (ARS) led by David Douds, Ph.D., show that the biological support system of mycorrhizal fungi are more prevalent and diverse in organically managed systems than in soils that depend on synthetic fertilizers and pesticides.

These fungi work to conserve organic matter by aggregating organic matter with clay and minerals. In soil aggregates, carbon is more resistant to degradation than in free form and thus more likely to be conserved. These findings demonstrate that mycorrhizal fungi produce a potent glue-like substance called glomalin that stimulates increased aggregation of soil



Mycorrhizal fungi structures enhance the ability of plant roots to access soil moisture and nutrients, produce stable compounds to sequester carbon dioxide as soil carbon , and slow decay of soil organic compounds.

particles. This results in an increased ability of soil to retain carbon. These findings are based on analysis by ARS researchers at the Northern Great Plains Research Lab in Mandan, North Dakota.



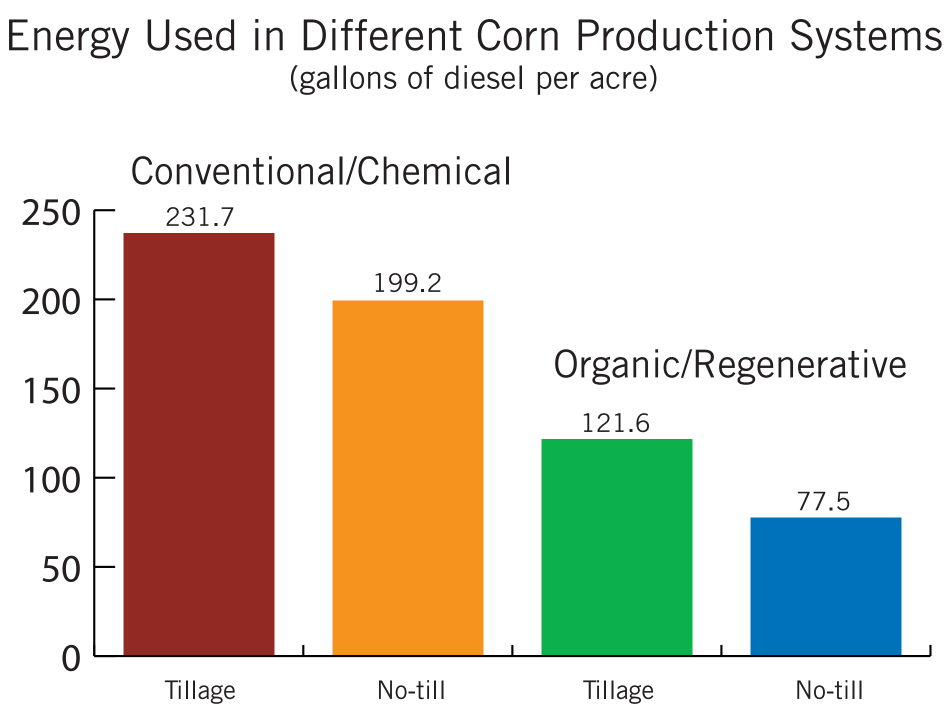
Soils improved over time through organic farming methods gain in stored organic matter, which enhances biological cycling of nutrients and management of water for the benefit of crops.

In Rodale Institute's FST, soil carbon levels increased more in the manure-based organic system than in the legume-based organic system, presumably because the manure stimulates the soil to sequester carbon in more stable forms. The study also showed that soil carbon depends on more than just total carbon additions to the system, because cropping diversity or carbon-to-nitrogen ratios of inputs may also have an effect. We believe the answer lies in the decay rates of soil organic matter under different management systems. The application of soluble nitrogen fertilizers in the petroleum-based system stimulates more rapid and complete decay of organic matter, sending carbon into the atmosphere instead of retaining it in the soil as the organic systems do.

Reducing emissions, maintaining yield, cutting chemical run-off

Beyond the benefit of carbon sequestration, regenerative practices bring dramatic reductions in energy use and carbon dioxide emissions.

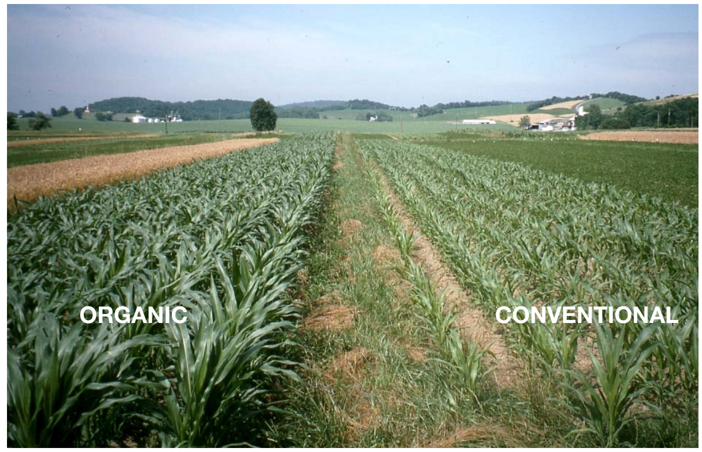
An energy analysis of the FST shows a 33-percent reduction in fossil-fuel use for organic corn/soybean farming systems that use cover crops or compost instead of chemical fertilizer. This translates to less



Regenerative organic systems sharply reduce energy use, according to research by David Pimentel, Ph.D.

greenhouse gas emissions as farmers adopt more regenerative production methods. Moreover, Rodale Institute's organic rotational no-till system can reduce the fossil fuel needed to produce each no-till crop in the rotation by up to 75 percent compared to standard-tilled organic crops. Research beginning this year at Rodale Institute will compare organic and petroleum-based no-till and tilled systems for the first time within the ongoing FST regime.

Research findings have shown that the biggest energetic input in a conventional, modern corn and soybean system is nitrogen fertilizer for corn, followed by herbicides for both corn and soybean production. The ability of regenerative organic agriculture to be a significant carbon sink and less dependent on fossil-fuel inputs has long-term implications for global agriculture and its role in air-quality policies and programs.



Better water infiltration, retention and delivery to plants helps to sustain yield during drought.

There are economic benefits beyond the reduced input costs to growers. Our FST showed that in all systems, corn and soybean yields from the organic systems matched the yields from conventional systems, except in drought years, when regenerative systems yielded about 30 per cent more corn than the petroleum-based system. This yield advantage in drought years is due to the fact that soils higher in carbon can capture more water and keep it available to crop plants.

Further, economic analysis by James Hanson, Ph.D., of the University of Maryland has shown that organic systems in Rodale Institute's FST are competitive in returns with conventional corn and soybean farming—even without market-based organic premiums. These have been consistent for more than a decade, with certified-organic crop prices ranging from 40 to 150 percent higher than standard crop prices.

Farming for carbon capture is also compatible with other environmental and social goals, such as reducing erosion and minimizing impact on native ecosystems.

Organically improved healthy soil develops high levels of complex organic compounds which are not readily water soluble yet create micropores that help to manage water better than non-organic soils.

This approach utilizes the natural carbon cycle to reduce the use of purchased synthetic inputs. Because chemical fertilizers and pesticides are not used, nutrient and chemical pollution in waterways is significantly reduced. Not only does this translate into long-term cleaner waterways, but it will also save in environmental cleanup costs at the state and federal level. The immensity of the societal cost of over-fertilization is illustrated by the watersheds feeding into the East Coast's Chesapeake Bay. Despite millions of dollars spent over the past 25 years to help farmers reduce agricultural nutrient losses to the bay, roughly 300 millions pounds of nitrogen (39 percent from agricultural sources) still reaches the bay annually.

Research and proofs

Rodale Institute's FST research was conceived as a way to test the assumptions about organic farming methods in a systematic way that would be scientifically rigorous and practically relevant on a large scale.

Data from nearly three decades of research trials indicate that wide-scale implementation of established, scientifically researched and proven practical farming methods will change agriculture from a global warming contributor to a global warming inhibitor, from a problem to a solution.

In the FST organic plots, carbon was sequestered into the soil at the rate of 875 lbs/ac/year in a crop rotation utilizing raw manure, and at a rate of about 500 lbs/ac/year in a rotation using legume cover crops.

During the 1990s, results from the Compost Utilization Trial (CUT) at Rodale Institute—a 10-year study comparing the use of composts, manures and synthetic chemical fertilizer—show that the use of composted manure with crop rotations in organic systems can result in carbon sequestration of up to 2,000 lbs/ac/year. By contrast, fields under standard tillage relying on chemical fertilizers lost almost 300 pounds of carbon per acre per year. Storing—or sequestering—up to 2,000 lbs/ac/year of carbon means that more than 7,000 pounds of carbon dioxide are taken from the air and trapped in that field soil.

In 2006, U.S. carbon dioxide emissions from fossil fuel combustion were estimated at nearly 6.5 billion tons. If 7000 lb/CO2/ac/year sequestration rate was achieved on all 434 million acres of cropland in the United States, nearly 1.6 billion tons of carbon dioxide would be sequestered per year, mitigating close to one quarter of the country's total fossil fuel emissions.

This is the emissions-cutting equivalent of taking one car off the road for every two acres under organic regenerative agricultural management, based on a vehicle average of 15,000 miles per year at 23 mpg (U.S. EPA).

Organic agricultural practices are established and have been successfully commercialized, and we believe that these methods are applicable in all scale operations as shown by farmers across the United States—from family truck farms to commercial operations of many thousands of acres.

Four European countries have changed their emission-reduction targets for the Kyoto Protocol to include contributions from organic agriculture policy based on Rodale Institute research. These are: the United Kingdom, the Netherlands, Germany and Denmark. France has recently invited Paul Hepperly, Ph.D.—research director at Rodale Institute—as a contributing scientist in their exploration of how organic agricultural practices can be useful in fighting greenhouse gases.

Challenges to success

The technology, techniques and practices of regenerative organic agriculture are proven. Research provides a sound basis for a national phasing out of environmentally harmful agricultural methods and phasing in of regenerative organic systems.

Widespread implementation will dramatically benefit from additional support for research and development. For example, more research is needed on the mechanisms responsible for the deep carbon sequestration we see in organically managed agricultural soils and forests. The role of mycorrhizae and glomalin in soil carbon retention requires further investigation, as do other biological mechanisms that result in greater ability to sequester carbon naturally and improve soil properties. While these methods have been replicated in a variety of soils and climates—from California to Senegal—further research is needed to systematically measure carbon-sequestration results in various soils, climates and crops. To date, Rodale Institute's FST and ARS researchers at Beltsville have studied rotations using mainly grains, and UC Davis has tested cotton and tomatoes.

Measurement of carbon in soil is also key. For widespread commercialization, better tools are needed for more predictive, quicker and more precise in-field soil-carbon measurement. Rodale Institute is currently testing mineralization of soil nitrogen as a way to estimate soil carbon levels. Another opportunity that may show great potential is analysis of satellite views of the earth to determine soil-carbon amounts. This approach requires taking into consideration yearly global carbon flux dynamics that track carbon and carbon dioxide flows between atmospheric and biospheric (terrestrial and oceanic) sources, driven in part by seasonal changes of photosynthetic activity.

Knowledge of carbon sequestration in forestry, range and pasture land needs to be combined and evaluated with Rodale Institute's research to gain a global terrestrial perspective on how much carbon could be sequestered to mitigate global warming.

The economic implications of improved soil health, increased biodiversity, improved human health, water savings, stream and bay cleanup, as well as climate change mitigation also need to be evaluated to help shape public policy and international accords.

While research needs are clear, data from research trials and commercial practice have established that the obstacles to nationwide implementation are neither technical nor economic. Rather, the largest obstacles to success are human factors. Public education, cause marketing, retraining—these are the types of programs needed to change behaviors in both farming practices as well as the way people shop and buy. Consumers may be ahead of the market in this case. Demand for organic, no-pesticide and hormone-free products in the United States has increased 20 percent or more each year for the past 14 years. Yet there has only been a 3-percent increase in acres dedicated to organic practices.

Public education, training in organic regenerative farming and public policy

The current environmental emergency requires a major paradigm shift in the way we provide incentives for our farmers. Incremental changes over a period of many decades are a prescription for continued global warming and other environmental degradation.

Successful implementation of regenerative organic farming practices on a national basis will depend on two factors: a strong bottom-up demand for change, and a top-down shift in state and national policy to support farmers in this transition.

Rodale Institute's experience in training thousands of farmers from around the world has proven that the shift to regenerative farming practices is both doable and practical. It's the decision to change that's hard. Government farm policy must be transformed in a way that incentivizes farmers and drives behavioral change toward wide-scale adoption of regenerative farming practices. Success requires a sustained, multi-faceted national public education campaign, training for farmers in regenerative agricultural methods and legislative action.

From a climate change and global warming perspective alone, it would seem imperative that the 2012 Farm Bill replace the system of commodity payments with a program that rewards farmers for conservation and other carbon-enhancing farm practices. Farmers should be paid on the basis of how much carbon they can put into and keep in their soil, not only how many bushels of grain they can produce. Incentives will encourage resource conservation and other carbon-enhancing means of producing crops for food, feed and fiber. The current, antiquated method of paying for a single year's crop would be eliminated.

Rodale Institute's research demands a Farm Bill paradigm shift that invests in environmentally sound systems and monetizes the ecological cost of fossil-fuel use (directly as fuel and indirectly in the manufacture of synthetic inputs for non-regenerative systems). In 2008 global food demand is testing the capacity of petroleum-dependent, export-focused commodity agriculture. This system has not served developed nations as food prices soar—inflamed by biofuel demand and fuel prices—and greenhouse gas emissions increase. It has especially hurt developing nations already struggling with food security issues.

Further, U.S. subsidies allow its exported commodity crops to be sold at artificially low prices in foreign markets, running afoul of World Trade Organization (WTO) provisions for free trade. The United States has lost every major challenge to these "trade distorting" subsidies before the WTO, but has yet to seriously explore the EU approach of "green payments" that support ecological services apart from yield.

The following chart outlines some comparative differences between the current Farm Bill structure—which rewards high-volume production of commodities such as wheat, soybeans, corn and oilseeds—and the proposed carbon-reward system of incentives.

CARBON FOCUSED	COMMODITY FOCUSED
Improves crop biodiversity – Rewarding all farmers, regardless of crops & acreage, for carbon stored will stimulate a variety of crops, rather than traditional commodity crops. Crop rotations also allow soil to replenish itself	**Limits crops** – Limiting financial incentives to commodity crops – corn, soybeans, wheat, rice, cotton – directs farmers to choose same small number of crops. Growing single crops each year also depletes nutrients from the soil
Rewards "green" practices – Regenerative methods reduce greenhouse gas emissions, avoid waterway pollution, limit erosion, and improve soil health	**Environmentally harmful** – Petroleum-based inputs release greenhouse gases, leach nitrogen and phosphorus into the water and deplete naturally occurring soil nutrients, making it more dependent on chemical fertilizer
Economically independent – By creating an integrated system that doesn't depend on artificial inputs tied to historically increasing petroleum prices, farmers are more economically independent	**Petroleum-industry dependent** – Farmers' profits are tied to increases in petroleum-based fertilizer and pesticide prices, creating a cycle of dependency
Long-term strategic land use – More perennial crops, including pasture and trees, focused on land stewardship to create a holistic farm plan	**Short-term field focus** – Annual crops (tilled and no-till) are the main focus on a year-to-year basis.
Reduces Erosion – More acres covered with growing crops for more months of the year reduce the risk of soil erosion	**Erosion-prone** – Current systems that leave fields fallow for large portions of the year are much more vulnerable to soil loss
Energy saving – Reduces or eliminates petroleum-dependent chemical fertilizer and pesticide inputs. Integrated systems reduce need for artificial inputs with high energy costs.	**High energy use** – Continues and increases use of petroleum-dependent chemical fertilizer and pesticide inputs that take a great deal of energy to produce and transport.
Spurs independent, entrepreneurial seed production – Increases demand for a broader range of crop seeds with carbon benefits, spurring new growth in regional and entrepreneurial seed companies that are often independent of input producers.	**Generates dependence on monopolistic seed and input companies** – Continues concentration of seed production focused on high-input varieties that trap farmers into cycle of dependency with a few large companies producing a small variety of crops.
Opens marketplace – Creates non-traditional opportunities to enter commercial markets, meeting surging demand for local and regional production in the Midwest and East. Allows more diverse farmers into the market	**Discourages new farmers and innovative crop production** – Commodity programs include strong disincentives that discourage commodity crop farmers to diversify.

Section Seven: A Call to Action

Compared to expensive, experimental, high-technology projects, global transition to biologically based farming can be achieved without new technology or expensive investment. Changing the emphasis from commodity to carbon will profoundly affect the economic drivers at the farm level. Farmers will creatively adapt to this economic prescription and shift to ecologically sound agricultural practices as they fulfill consumer demand, supported by a practical policy that makes a transition to these practices economically feasible.

With a problem so dire, a need so urgent, and a solution so available, the path to responsible terrestrial stewardship is clear. And because the practices of 21st Century regenerative organic agriculture are scalable globally, it's a solution that can be adapted all over the world.

Literature Cited

Khan, S., Mulvaney, R., Ellsworth, T., and C. Boast. 2007. The myth of nitrogen fertilization for soil carbon sequestration. J. Environ. Qual. 36:1821-1832.

Jareek, M.K., and R. Lal. 2005. Soil organic carbon sequestration rates in two long term no-till experiments in Ohio. Soil Science 170(4):280-291.

Pimentel, D., Hepperly P., Hanson, J., Douds, D., and R. Seidel. 2005. Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. Bioscience 55 (7):573-582.

Pimentel. D., 2006 Impacts of organic faming on efficiency and energy use in agriculture. www.organicvalley.coop/fileadmin/pdf/ENERGY_SSR.pdf. 40 pages.

Teasdale, J., Coffman, C., and R. Mangum. 2007. Potential long-term benefits of no-tillage and organic cropping systems for grain production and soil improvement. Agron. J. 99:1297-1305.

Veenstra, J., Horwath, W., Mitchell, J. and D. Munk. 2006. Conservation tillage and cover cropping influences soil properties in San Joaquin Valley cotton-tomato crop. California Agriculture 60(3):146-152.

Resources

Bolin, B., E. Degens, S. Kempe, and P. Ketner. 1979. The Global Carbon Cycle. Wiley, New York.

Chen, Y., and Y. Avimelech. 1986. The Role of Organic Matter in Modern Agriculture. Martinus Nijhoff Publishing, The Hague.

Douds, David D. Jr, R. R. Janke, and S. E. Peters. 1993. VAM fungus spore populations and colonization of roots of maize and soybean under conventional and low input sustainable agriculture. Agriculture, Ecosystems, and Environment 43: 325-335.

Douds, David D. Jr., and P. D. Millner. 1999. Biodiversity of arbuscular mycorrhizal fungi in agroecosystems. Agriculture, Ecosystems, and Environment 74:77-93.

Douds, D., Hepperly, P., Seidel, R., and K. Nichols. 2007. Exploring the role of arbuscular mycorrhizal fungi in carbon sequestration. Proceedings of the 2007 Annual Meeting of the American Society of Agronomy in New Orleans.

Drinkwater, L.E., Wagoner, P. and M. Sarrantonio. 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. Nature 396:262-265.

Hepperly, P., Seidel, R., Pimentel, D., Hanson, J., and D. Douds, Jr. 2007. Organic farming enhances soil carbon and its benefits. Pages 129-153 in Soil Carbon Management: Economic, Environmental, and Societal Benefits, J. Kimble, C. Rice, D. Reed, S. Mooney, R. Follet, and R. Lal eds. CRC Press, Boca Raton, 268 p.

Hepperly, P., Douds, D., and R. Seidel. 2006. The Rodale Institute Farming Systems Trial 1981 to 2005: Long term analysis of organic and conventional maize and soybean cropping systems. Pages 15-31 in Long Term Field Experiments in Organic Farming. J. Raupp, C. Pekrun, M. Oltmanns, and U. Kopke eds. ISOFAR, Verlag Dr. Koster, Berlin 198 p.

Hepperly, Paul. 2003. Organic farming sequesters atmospheric carbon and nutrients in soils www.newfarm.org/depts/NFfield_trials/1003Ocarbonwhitepaper.shtml/ accessed 12-9-07.

Lotter, D., Seidel, R., and W. Liebhardt. 2003. The performance of organic and conventional cropping systems in an extreme climate year. American Journal of Alternative Agriculture 18(2):1-9.
Nebel, Bernard J., and Richard T. Wright. 1996. Chapter 16. Major Climatic Changes in The Way The World Works Environmental Science Fifth Edition. Prentice Hall, Upper Saddle Rive, New Jersey. 687 p.

Paul, E. A., and F. E. Clark.1989. Chapter 6 Carbon cycling and soil organic matter in Soil Microbiology and Biochemistry. Academic Press, New York. 271 p.

Pennsylvania Environmental Council. 2007. Pennsylvania Climate Change Roadmap. www.pecpa.org/FINAL%20PEC%20Roadmap%20Complete%20Report.pdf.

Pfeffer, D. 2004. Eating fossil fuel. www.fromthewilderness.com/free/ww3/100303_eating_oil.html.

Puget, P., and L. Drinkwater. 2001. Short term dynamics of root and shoot-derived carbon for a leguminous green manure. Soil Sci. Soc. Am. J. 65:771-779.

Reider, C., Herdman, W., Drinkwater, L., and R. Janke. 2000. Yields and nutrient budget under composts, raw dairy manure, and mineral fertilizer. Compost Science 8(4):328-339.

Rillig, M., and S. F. Wright. 2002. The role of arbuscular mycorrhizal fungi and glomalin in soil aggregation. Plant and Soil 234:325-333.

Rillig, M., S. F. Wright, K. Nichols, W. Schen, and M. Torn. 2001. Large contribution of arbuscular mycorrhizal fungi to carbon pools in tropical forest soils. Plant and Soil 233:167-177.

Sanchez, P., M. P. Gichuru, and L. B. Katz. 1982. Organic matter in major soils of the tropical and temperate regions. Proc. Int. Soc. Soil Sci. Cong. 1:99-114.

Sedjo, Roger A. Brent Sohngen and Pamela Jagger. 1998. RFF Climate Issue Brief #12
Stevenson, F. 1982. Humus Chemistry: Genesis, Composition, and Reactions. Wiley Interscience, New York. 583.

Stevenson, F. 1985. Cycles of Soil Carbon, Nitrogen, Phosphorus, Sulfur and Micronutrients. John Wiley and Sons, New York. 380 p.

Wander, M., S. Traina, B. Stinner, and S. Peters. 1994. Organic and conventional management effects on biologically active soil organic matter pools. Soil Sci. Soc. Am. J. 58: 1130-1139.

Wright, S. F., and R. Anderson. 2000. Aggregate stability and glomalin in alternative crop rotation for the Central Plants. Biology and Fertility of Soil 31:249-253

Wright, S., and A. Upadhyaya. 1998. A survey of soils for aggregate stability and glomalin, a glycoprotein produced by hyphae of arbuscular mycorrhizal fungi. Plant Soil 198:97-107.

Addendum

Rodale Institute: An overview of our work with organic and sustainable farming

Summary

Rodale Institute is located on a 333-acre certified organic farm in Kutztown, Pennsylvania and has spent 60 years doing extensive research to provide farmers with the know-how, tools and techniques they need to succeed, policy-makers the information they need to best support our farmers and consumers with the resources they need to make informed decisions about the food they buy and eat both in the United States and abroad.

From aquaculture and amaranth studies to vetch varietals trials and design and experimentation with a cutting-edge roller-crimper tool for low-cost, low-input no-till, the on-farm and collaborative research of the Rodale Institute has spanned the width and breadth of agriculture. The farm is perhaps best known for its Farming Systems Trial® (FST), the United State's longest-running scientific experiment specifically designed to compare organic and conventional farming practices.

Brief History

The Institute was created by visionary J.I. Rodale who moved from New York in the late 1930s to rural Pennsylvania, where he was able to realize his keen personal interest in farming. He learned about organic food-growing concepts being promoted by Lady Eve Balfour and Sir Albert Howard and theorized, based on their work and his own observations, that to preserve and improve our health we must restore and protect the natural health of the soil. Developing and demonstrating practical methods of rebuilding natural soil fertility became J.I. Rodale's primary goal when World War II's sudden shortage of nitrogen fertilizer – diverted to making munitions – exposed the natural nutrient poverty of the nation's soil. In 1947, J.I. founded the Soil and Health Foundation, forerunner to the Rodale Institute. He also created successful periodicals, including *Health Bulletin, Organic Farming and Gardening and Prevention* magazines.

The concept of "organic" was simple but revolutionary in the post World War II era. Manure, cover crops and crop mixtures were standard practices through World War I, but chemical fertilizers, pesticides, herbicides, artificial ingredients, preservatives and additives for taste and appearance in the years since the war had rapidly changed agriculture. As J.I. Rodale communicated the idea of creating soil rich in nutrients and free of contaminants, however, people began to listen and acceptance grew.

J.I. Rodale died in 1971. His son Robert expanded the farm and health-related research with the purchase of the 333-acre farm near Kutztown, Pennsylvania. With his wife Ardath, Robert established what is now the Rodale Institute and an era of research began that continues today. Powerful testimony by Robert Rodale, and the farmers and scientists who swore by the sustainable methods pioneered at Rodale, convinced the U.S. Congress to include funds for regenerative agriculture in the 1985 Farm Bill. Today, federal, state and local governments, land-grant universities and other organizations nationwide are pursuing regenerative agriculture research and education programs.

When Robert Rodale was killed in a traffic accident in Moscow in 1990, Ardath Rodale became the Institute chairman and John Haberern became president. In 1999 Robert and Ardath Rodale's son, Anthony became chairman of the board. Anthony and Florence, his wife, developed outreach efforts to children during their period of active program involvement before Anthony became an international ambassador for the Rodale Institute's mission. Board member Paul McGinley became co-chair of the board with Ardath in 2005.

Timothy J. LaSalle became the first CEO of the Institute in July 2007, bringing decades of experience in academic, agricultural and non-profit leadership to the task. Under his guidance, the Institute champions organic solutions for the challenges of global climate change, better nutrition in food, famine prevention and poverty reduction.

TIMELINE

1941 — J.I. Rodale buys a farm near Emmaus, PA to test food-growing concepts promoted by Lady Eve Balfour and Sir Albert Howard.

1942 — "Plants are not like money," J.I. noted in the inaugural issue of Organic Farming and Gardening magazine. "A one-dollar bill always means 100 cents. But two different pea pods each representing the same weight do not have the same amount of vitamins."

1947 — Soil and Health Foundation, forerunner to the Rodale Institute, is founded by J.I. Rodale with the goal of developing and demonstrating practical methods of rebuilding natural soil fertility.

1950 — J.I. Rodale speaks about the merits of organiculture (a term he coined in 1948 to describe organic gardening) to the House Select Committee to Investigate the Use of Chemicals in Food.

1954 — "Organics is not a fad'" J.I. writes. "It has been a long-established practice - much more firmly grounded than the current chemical flair. Present agricultural practices are leading us downhill."

1971 — After J.I. Rodale's death, his son Robert and his wife Ardath expand the farm and health-related research with the purchase of a 333-acre farm near Kutztown, Pennsylvania, establishing what is now the Rodale Institute.

1978 — President Jimmy Carter charges Agricultural Secretary Bob Bergland to have USDA ARS personnel study alternative agriculture approaches including organic practices.

1981 — Rodale Institute works with USDA to start the Farming Systems Trial® (FST) studying the transition to organic production and comparing it to conventional agriculture. Robert Rodale first describes regenerative agriculture: "We must go beyond sustainability, to renew and to regenerate our agricultural resources."

1987 — Thanks largely to Robert Rodale's lobbying efforts, Congress passes the first-ever federal sustainable agriculture appropriation-$3.9 million—planting the seeds for the Sustainable Agriculture Research and Education (SARE) and Low Input Sustainable Agriculture (LISA) programs.

1988 — Organic systems from Rodale Institute's Farming Systems Trial® show comparable yield for corn, soybean and small grains in organic compared to conventional production

1990 — Organic Foods Production Act is signed into law as part of the Farm Bill and Robert Rodale dies in a traffic accident in Moscow. Ardath Rodale becomes the Institute chairman and John Haberern becomes president.

1991

The Rodale Institute sponsors the world's first International Conference on the Assessment and Monitoring of Soil Quality. More than two dozen specialists from five countries participate.

1993

Rodale Institute's Compost Utilization Trial begins comparing the use of composts, manures and synthetic chemical fertilizer.

1996

Rodale Institute's article in Nature shows organic management conserves carbon and nitrogen in the soil promoting productivity. ARS soil scientist Sara F. Wright discovers glomalin, soil "super glue," implicated as a key component of agricultural carbon sequestration.

2002

Organic systems in Rodale Institute's Farming Systems Trial are shown to have significantly higher yields under severe drought and environmental stresses.

2003

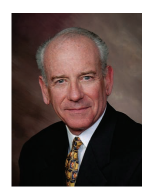
Rodale Institute research department calculates carbon sequestration in the Farming Systems Trial and develops white paper on the significant impact regenerative farming technique have on mitigating global warming.

2004

Rodale Institute research department calculates carbon sequestration in the Compost Utilization Trial and finds overwhelming evidence that regenerative farming techniques can become the single largest wedge to actively combating global warming.

2005

Rodale Institute, Cornell University, Maryland University and USDA ARS show carbon and nitrogen sequestration values, economics and energy efficiency of organic agriculture in Bioscience article. Anthony Rodale becomes chairman emeritus for the Rodale Institute, and Ardath Rodale and Paul McGinely take over as co-chairs.



2006

University of California Davis shows carbon sequestration levels in San Yoaquin Valley similar to Rodale Institute findings.

2007

University of Illinois at Morrow Plots shows nitrogen fertilizers do not contribute to carbon sequestration corroborating Rodale Institute Compost Utilization Trial results.

Henry A. Wallace Agricultural Research Center shows that organic farming can yield better soil quality and sequestration results compared to no-till alone.

Timothy J. LaSalle joins the Rodale Institute as the first CEO. Under his leadership, the Institute champions organic solutions for the challenges of global climate change, better nutrition in food, famine prevention and poverty reduction.